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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1Q(QKA); H3Q(CACA,CACX,QBMX); H4L(LECX)

Int Cl (Ed.6): H01Q(1/08, 1/24, 9/40, 9/42); H04B(1/38)

Other: Online: WPI, EDOC, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2292482 A	(PLESSY SEMICONDUCTORS) Whole document.	1, at least.
X	GB 2291542 A	(MOTOROLA) See page 1, especially.	1, at least.
X	WO 98/20578 A1	(SAMSUNG) Whole document.	1 and 6, at least.
X	WO 97/26713 A	(ERICSSON) See abstract.	1, at least.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

6. A folding mobile phone as in claims 1 to 5 in which the further conductive film incorporated with the second housing is a copper sheet formed on a PCB.

7. A folding mobile phone as in claims 1 to 5 in which the further conductive film incorporated with the second housing is a metallic finish applied to the outside of the second housing.

8. A folding mobile phone as in claims 1 to 5 in which the further conductive film incorporated with the second housing is applied to the inside of the second housing

9. A folding mobile phone as in any preceding claim in which the phone is a dual mode phone for operation in two network frequency bands.

10. A folding mobile phone as in any preceding claim in which the phone is a tri-mode phone for operation in three network frequency bands.

11. A folding mobile phone as in claim 9 in which the two network frequency bands are GSM 900 and PCN 1800.

12. A folding mobile phone as in claim 10 in which the three network frequency bands are DCS 1900, GSM 900 and PCN 1800.

11. A folding mobile phone as in any preceding claim in which the conductive film incorporated with the first housing surrounds a viewing window.

Claims

1. A folding mobile phone comprising two main housings, a first and second housing, said phone having an antenna switched between normal and standby positions, in the normal position the antenna acting as a monopole comprises in combination a conductive film incorporated with the first housing and a further conductive film incorporated with the second housing and in the standby position the antenna consists in the conductive film incorporated with the first housing, the further conductive film of the second housing acting as a ground plane.

2. A folding mobile phone as in claim 1 in which the area, in plan, of the conductive film incorporated with the first housing is greater than two thirds of the area in plan of the first housing.

3. A folding mobile phone as in claims 1 and 2 in which the conductive film incorporated with the first housing is a metallic finish on the outside of the housing.

4. A folding mobile phone as in claims 1 and 2 in which the conductive film incorporated with the first housing is a metallic finish on the inside of the housing.

5. A folding mobile phone as in claims 1 and 2 in which the conductive film incorporated with the first housing is formed on a PCB.

A conductive film may be applied to the inside surface of the housing instead of to the outside surface. By this means an inside profile of a housing may be directed toward antenna performance whereas an outside profile of a housing may be dictated by some other feature such as appearance.

Application of the conductive film to the housing may be by electro-plating, electroless-plating or other standard techniques. The conductive films must have a high conductivity, however and this must be taken into account when specifying the techniques for application and the materials to be used for the conductive films. The conductive film incorporated with housing **1** may be formed on a PCB in the same manner as described above for copper sheet **8**.

The switching required when the phone is moved between the standby and normal positions may be effected mechanically by means of a cam in the hinge mechanism. Alternatively an electronic switch may be used which would require a logic line to provide an indication of the open or closed state of the phone. These switching means are well known in the prior art.

The performance of the antenna in the closed position is shown in figure 6 which is a plot of reflection coefficient versus frequency. The measured attenuation with reference to 0 dBm at the points marked on the plot of figure 6 are:

X -5.0664dB at the frequency of 890 MHz
Y -2.2203 dB at 960 MHz
Z -3.5967 dB at1.710 GHz
T -4.0216 dB at 1.880 GHz

In this embodiment the conductive film **24** is shown as applied to the planar surface **21** and therefore is itself planar. It has been found empirically that the conductive film **24** may be applied to surfaces which depart considerably from the planar without significant loss of performance for the antenna. With reference to figures 1 and 2, the conductive film **24** covering the top surface **21** may be extended to cover the edges **22** of the housing **1** without significant loss of antenna effectiveness. The antenna as described can therefore be used with a range of housing profiles.

When the phone is in the normal (open) position, the conductive film **24** and copper sheet **8** in combination operate as a monopole antenna. Excitation of the antenna in the normal operating position is via a coaxial lead at **11** across the edges of the two conductive films **8** and **24**. The antenna in the normal position is not resonant within the frequency bands of operation and has a wide band response. Resonance is constrained by the width (area) of the high conductivity film **24**.

The wide band performance of the antenna in the open position of the phone is exhibited in figure 5 which is a plot of reflection coefficient versus frequency for the antenna. The measured attenuations with reference to 0 dBm at the points marked on the plot of figure 5 are:

P, -10.519 dB at the frequency 890 MHz
Q, -10.168 dB at 960MHz
R, -8.9401 dB at 1.71GHz
S, -7.3923 dB at 1.88 GHz

When the phone is closed into the standby position, the conductive film **24** overlays in parallel spaced relationship the copper sheet **8** as illustrated in figure 4. In the standby position, only the conductive film **24** is fed at **12** via a matching circuit as shown in figure 7 and the copper sheet **8** acts as a ground plane. The antenna in the standby position operates in the manner of a patch antenna.

Various surfaces may have a conductive metallic finish applied to them. In this example the top surface **21** has applied to it a metallic finish so as to provide a conductive film **24** as well as to provide a desired cosmetic appearance. The conductive film **24** is applied to the whole of the top surface **21** except for the window **4** and forms part of the antenna of the phone. If window **4** was not required then conductive film **24** would conveniently be applied to the whole of the top surface **21.** The conductive film **24** has an overall length of $97*10^{-3}$ metres, an overall width of $55*10^{-3}$ metres and a thickness of $15*10^{-6}$ metres. The dimensions of the window **4** are width $32*10^{-3}$ metres and length $26*10^{-3}$ metres. The conductive film **24** surrounds the window **4**.

For satisfactory results the area, in plan, of the conductive film **24** incorporated with the first housing should be greater than two thirds of the area, in plan, of the first housing. The area, in plan, of the first housing should be taken to include the area of window **4**.

Within bottom section **2** is a copper sheet **8** having an area slightly less than the area in plan of bottom section **2** . The dimensions of copper sheet **8** are $97*10^{-3}$ metres length , $55*10^{-3}$ metres width and thickness of $15*10^{-6}$ metres. Copper sheet **8** is formed as a conductive film upon a PCB by standard manufacturing techniques and the position of copper sheet **8** is indicated in figure 3. The plan view of figure 3 illustrates the extent and position of the two conductive films and the location of the antenna feed **11**.

figure 5 is a plot of antenna reflection coefficient in the open position,

figure 6 is a plot of antenna reflection coefficient in the closed position,

figure 7 is a matching circuit used in the closed position,

With reference to figure 1, a folding phone comprising two main housings connected by a hinge is shown in the open position with a first housing as the top section of the phone at **1** and a second housing as the bottom section of the phone at **2**. When the phone is closed a window **4** in the top section **1** gives visual access to the visual display **5** located in the bottom section **2**.

The phone operates in dual mode. That is to say it may be used to communicate with networks operating in either of the two frequency bands GSM 900 and PCN 1800. The GSM system (Global System for Mobile communications formerly Groupe Special Mobile) operates in the band 890 to 900 megahertz and the PCN system (Personal Communications Network) operates in the band 1710 to 1880 megaHertz. The phone incorporating an antenna according to the present invention is not restricted to dual band use and may be operated in a third band (Tri-band operation) e.g. DCS 1900 (Digital Cellular Service) operating around 1900 MHertz.

The top section **1** houses a microphone and connecting leads and the other components necessary for a mobile phone are housed in bottom section **2**. Operation of the phone and incorporation of the antenna does not depend on the inclusion of window **4**.

Conveniently the top section of the phone will include a window for providing viewing access to a display screen or direct access to part of a keypad when the phone is in the closed position. The display screen and keypad would usually be located in the bottom section of the phone.

According to the invention there is provided a folding mobile phone comprising two main housings, a first and second housing, said phone having an antenna switched between normal and standby positions, in the normal position the antenna acting as a monopole comprises in combination a conductive film incorporated with the first housing and a further conductive film incorporated with the second housing and in the standby position the antenna consists in the conductive film incorporated with the first housing, the further conductive film of the second housing acting as a ground plane.

One example of the invention will now be described with reference to the figures in which:

figure 1 shows a foldable phone in the normal position,

figure 2 shows a foldable phone in the standby position,

figure 3 is a plan view of the phone in the open position,

figure 4 is a side view illustrating the antenna in the closed position,

Mobile phone with incorporated antenna.

This invention relates to mobile phones and in particular it relates to folding mobile phones having an incorporated antenna.

The design of antennas for mobile phones capable of operation in more than one frequency band (dual mode or tri-mode) is constrained by the market demand continually to reduce the overall size of portable phones. Preference by many customers for external metallic finishes on the phone housings can also increase the difficulty of antenna design.

The volume occupied by the antenna and associated circuitry and their costs are important factors for a satisfactory design as well as antenna effectiveness over a sufficiently wide operating bandwidth. Preferably the antenna will be incorporated into the phone so that it is not noticeable by the user.

A typical foldable phone is illustrated in figures 1 and 2 and comprises two main sections connected by a hinge mechanism. The phone is normally used in the open position as shown in figure 1 but incoming calls as well as text and data messages must be received when the phone is in the closed position as shown in figure 2. Performance of the antenna when the phone is in the closed position must be sufficient to allow the satisfactory reception of the incoming calls.

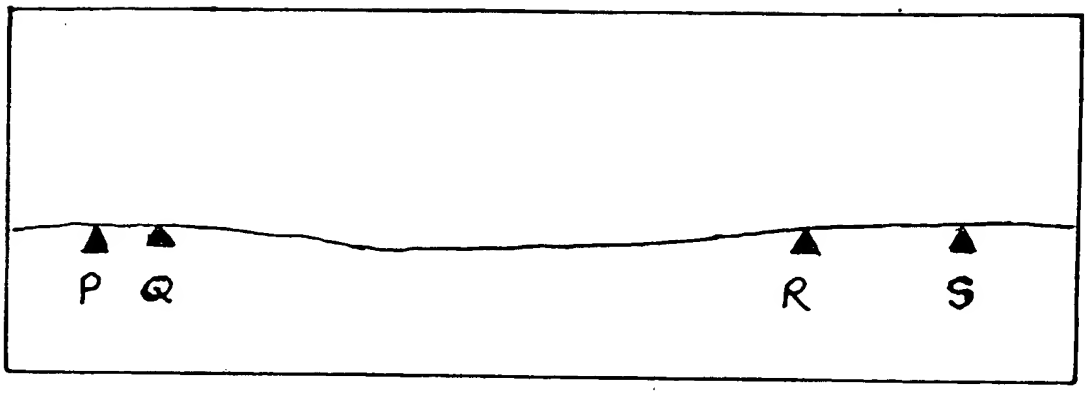


Fig 5

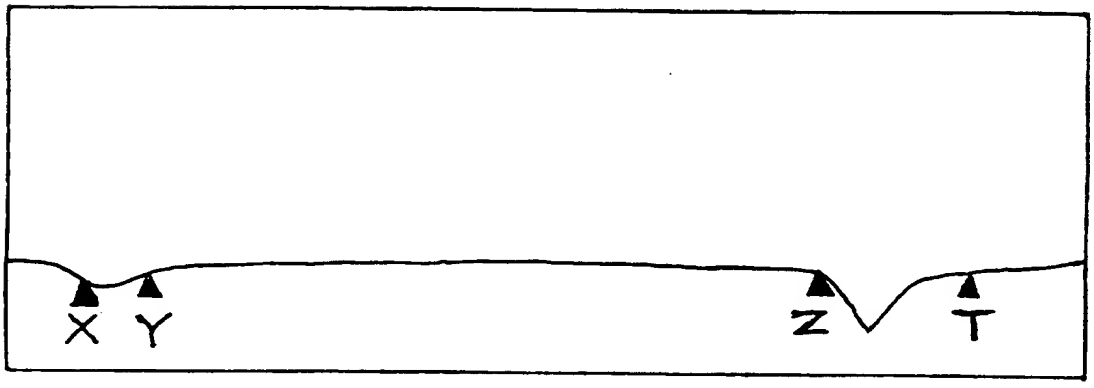


Fig 6

Fig.4.

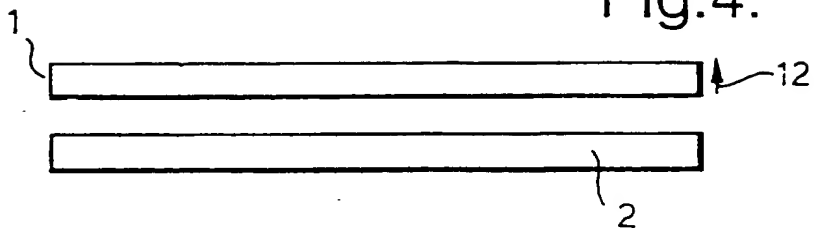
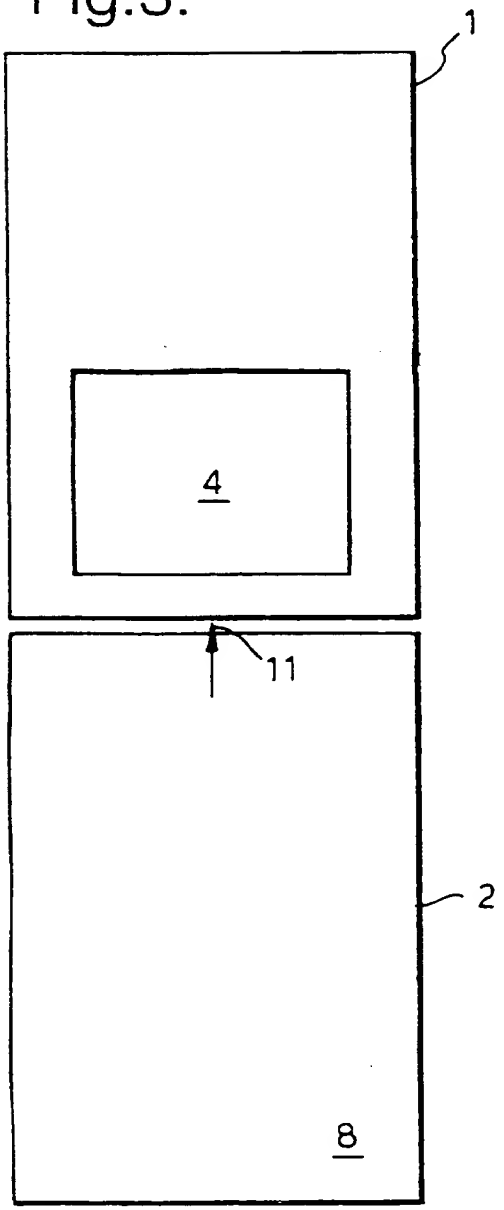


Fig.3.



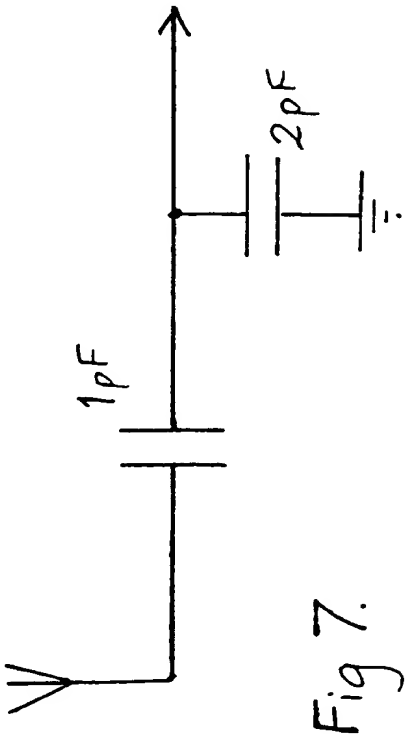


Fig 7.

Fig.1.

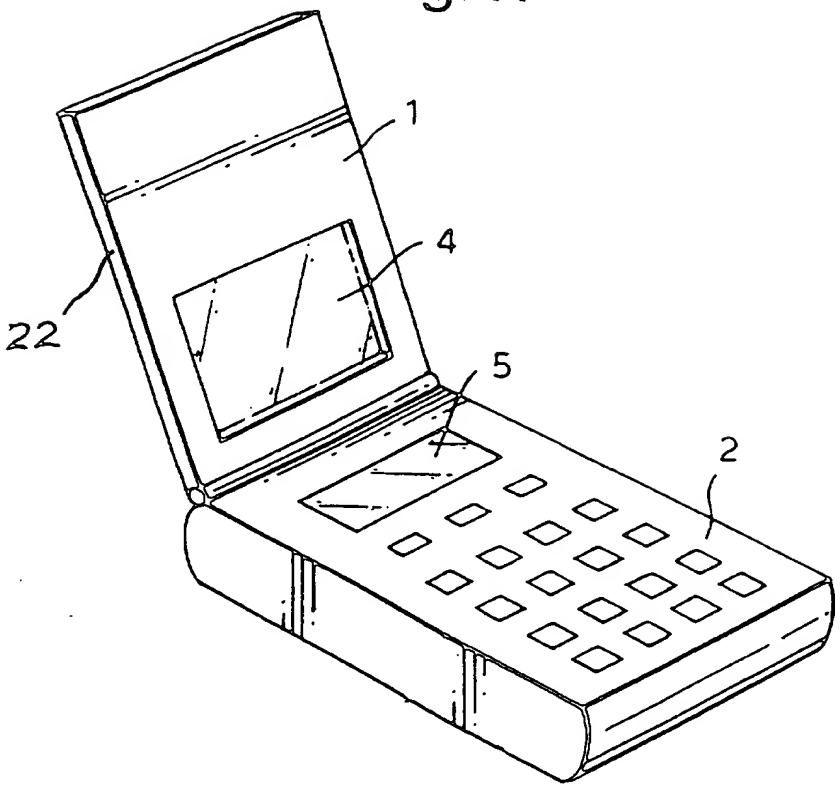
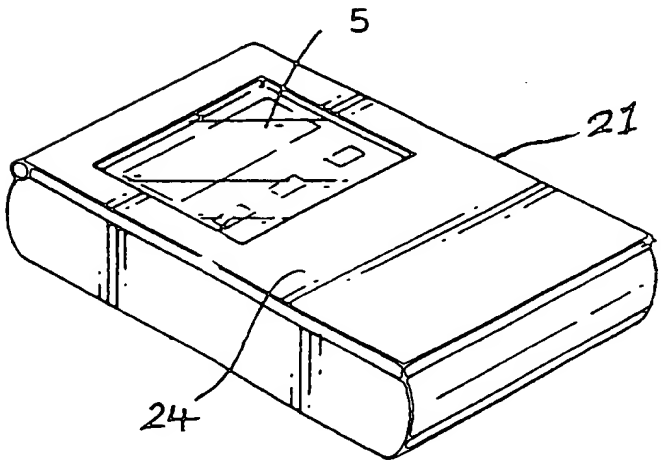


Fig.2.



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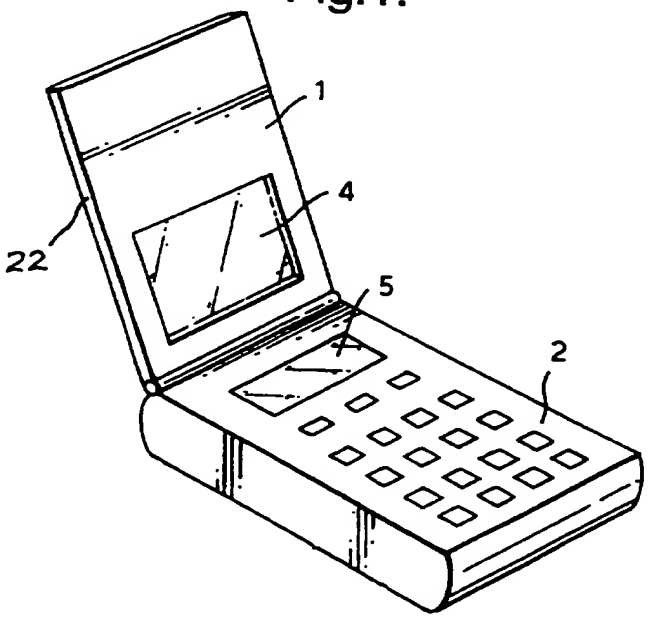
(54) Abstract Title
Mobile phone with incorporated antenna

(57) A folding mobile phone has first and second housings, and an antenna switchable between normal and standby positions. In the normal position the antenna acts as a monopole in combination with a conductive film incorporated with the first housing and a further conductive film incorporated with the second housing, and in the standby position the antenna includes the conductive film incorporated with the first housing, and the further conductive film of the second housing which acts as a ground plane.

Fig.1.



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